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ABSTRACT

Investigated was the question of whether understanding is explained by means of concepts referring to tasks, being domain-specific for certain subject matter areas, or is it explained by concepts which extend across tasks and are not domain-specific? Also explored were: (1) which explanatory concepts are present, that is, which steps and conditions of understanding are thematized in the explanations? and (2) do explanatory concepts differentiate according to success and failure in understanding or by sex? A two-dimensional table was constructed for coding explanations of 20 male mathematics teachers in grades 5 and 6 of schools in West Germany. Results indicated a marked predominance of explanations referring to domain-specific tasks as compared to explanations extending across tasks. The order of frequency of steps and conditions of understanding are noted, and sex differences in a few categories were found. The discussion focuses on: (1) reference to the task and type of explanation; and (2) obtaining explanations referring to task: problems and opportunities. (MNS)

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OCCASIONAL PAPER 58 NOVEMBER 1984

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Students' "Understanding" of Tasks in the View of Mathematics Teachers

by Rainer Bromme & Katharina Juhl

Problem

"Understanding" the subject matter is an essential part of the process of learning in school. To facilitate "understanding" thus is the core of the teacher's profession. In doing so, he must not only align the presentation of the subject matter to the "logic" of the content itself, but also to the pupils' respective level of understanding (Lesh & Landau, 1983). In order to adapt the presentation of the subject matter to the structures of knowledge already existing in the pupils and in order to be able to counter pupil errors and misunderstandings, the teacher must be able to explain successes and failures of pupil understanding in the classroom to himself. The question to be studied is which explanations teachers have for understanding under usual classroom conditions (teaching in classes of 25 – 30 pupils with heterogenous achievement levels). The problem of task understanding has been selected here as mathematics is predominantly taught by working with tasks (Hopf, 1980). Explaining, treating, and discussing tasks requires the largest part of time in mathematics instruction.

The explanations offered by teachers for the achievement results of longer teaching sequences (marks for tests or in reports) have been extensively thematized within approaches of attribution theory. As opposed to that, teacher explanations for the understanding of individual tasks have seldom been examined. In attribution theory approaches the focus of interest has been mainly on explanatory dimensions such as "stable – unstable", "internal – external"(Meyer & Butzkamm, 1975), or"social vs. individual norms of reference"(Rheinberg, 1980; an overview is given by Allmer, 1983).

This research, however, also yielded evidence that the respective academic subject will influence teacher explanations. Thus, teacher explanations of pupil achievement given for mathematics would seem to differ from those given for German(Hofer, 1975). If there are such "subject – specific" differences in teacher explanations of achievement results (marks), there is a distinct possibility that characteristics of the subject matter within a subject enter into teacher explanations of processes of understanding.

It was also shown in connection with other questions of research on teaching that the content of the subject matter plays an important role in the thinking of teachers while they are coping with professional demand, and this is particularly the case when the lessons themselves and lesson – preparing are studied. The particular impact of subject – matter – specific thinking and decisions was shown for the very objectives of teacher behavior which have traditionally been considered to be unspecific with regard to subject matter, like, for instance, maintaining discipline. Thus, successful teachers attain discipline not by a "special" system of reinforcements and sanctions, but rather by giving precise and early indications to the pupils as to what they

+ We are greatful to Prof. Dr. M. Hofer for his helpful criticism of an earlier version of this paper.

are to do, and when (Brophy, 1979). Similar conclusions seem to hold for maintaining pupil motivation (Brophy, 1983). The teachers' thinking upon lesson preparing mainly refers to the subject matter as well (Bromme 1981). This does not mean that the pupil is not taken into account, but information about the pupil is always used with reference to the content of the subject matter (Clark & Peterson, 1984). If questions which do not immediately thematize the acquisition of the academic subject matter already yield clear evidence of subject-matter-specific thinking, the possiblitiy of a strong reference to the subject matter may be all the more expected in explanations of "understanding". Within the context of research into the professional knowledge of teachers (Bromme & Brophy, in press), it is now of interest *how the content of the subject matter is integrated into explanations of understanding.* Hence, the topic of this paper is to investigate the question whether understanding is explained by means of concepts referring to tasks and domain specific for certain subject-matter areas, or by means of concepts which extend across tasks and which are not domain specific.

The concepts of explanations referring to tasks domain specific concepts are among others, the special previous knowledge which is required to understand a task, the particular problems a pupil has with the textual frame of a mathematical task, etc.

Concepts of explanation extending across tasks and unspecific areas are, among others, the support the pupil has at home, his ability to concentrate, his ability to memorize. Certain concepts of explanation can be used both as referring to task and extending across tasks, such as motivation fo certain task types or working behavior (does not like executing triangle constructions vs. is not interested in school).

In view of the insuffient knowledge about teachers explanations of the understanding of individual tasks, a systematization of explanations would seem to be desirable. This is why the explanations obtained will be described after having been coded by means of scientific (i.e. psychological) concepts of explanation. The process of understanding has mainly been thematized in problem solving research. Beyond that, educational conditions such as teacher behavior and pupil behavior as well as variables of motivation theory and theory about giftedness are part of the scientific explanation of understanding. It is thus a matter of establishing a first comparison between "professional",i.e. teachers' models of explanation and the scientific model of explanation – but not of evaluating the former. Psychological concepts of understanding shall serve as an organizing frame in order to facilitate systematization of teacher statements.

Further information about teacher explanations may be offered by distinguishing according to whether successful understanding is explained, or failure to understand. The explanations obtained will thus be examined closer with regard to this distinction. Finally, the explanatory differences between academic subjects mentioned above (Hofer, 1975) have also yielded evidence that such differences will also depend on the pupils' sex. Thus, for instance, mathematics – as opposed to languages – is considered to be a 'male' subject matter, as girls lack interest and talent for it, a finding considered particularly salient in the areas of geometry and higher algebra, and less evident in the field of less complicated calculating skills (Badgear, 1981).

Hence, the following questions will be treated:

1. *Is understanding explained by concepts referring to tasks and domain-specific, or by concepts which extend across tasks?*

2. *Which explanatory concepts are present, i.e. which steps and conditions of understanding are thematized in the explanations?*

3. *Does the preference of explanatory concepts differentiate*
   a) according to successful understanding and failure to understand?
   b) according to boys' and girls' understanding?

Method of Obtaining Data

In order to answer the question, it is necessary to make the respective task which is to be understood and the pupil's person equally salient. For this purpose we constructed – inspired by Kelly's Grid (Kelly, 1955) – a two-dimensional table, into which the teachers questioned had to enter a task chosen at random from a lesson belonging to their most recent teaching unit. Into the lines of the left column, the teachers were asked to insert, respectively, two pupils (first names), who had understood the task and two who had not. These children had to be selected from a list of 7 boys and 7 girls established beforehand in alphabetical order. This limitation was necessary in order to prevent potential bias by unequal distribution of sexes. Subsequently, the teacher was to recall the causes of understanding/ non-understanding, and to insert these into the lines of the table (see fig. 1).

PLEASE INSERT FIG 1 HERE

Hence, each teacher has worked on 5 tasks selected by himself. This resulted in 10 explanations of understanding and 10 explanations of non-understanding for each teacher. Each of these explanations might consist of one or several causes named. The teacher's explanations were obtained literally in order to avoid suppressing conceptual differentiations and variability. An additional questionnaire was used to obtain the pupils' most recent grades, their sex, the teaching sequence and the textbook from which the tasks had been taken, and data concerning the teacher's education and professional experience.

Data Collection and Sampling+

Data collection was based on 20 subjects teaching mathematics to a fifth or sixth grade at various grammar schools (Gymnasien). The mean professional experience of these teachers was approx. 6 years (min. 1 year, max. 12 years). Participation was remunerated.

All the respondents had taken full-scale studies in mathematics. Only male teachers were included in order to keep the potential influence of sex on explanation constant (Schildkamp & Kündiger, 1982, p. 7-9).

+ Data collection and data analysis were assisted by Gudrun Dobslaw, Gerd Mannhaupt, Elisabeth Schulze and Rositta Symalla.

Data Analysis

A system of coding was constructed for evaluating the teachers' free answers. It contains an equal number of categories referring to tasks (i.e.domain – specific) and of categories extending across tasks, and two residual categories. The coding system was constructed after a survey both of the literature on understanding as a cognitive process and of studies of teacher explanations which discussed personal, task, and teaching variables. The system was tested in a pretest and had been established before data collection began. The abbreviations of the categories are given in table 1 (see below).

For the process of understanding mathematical tasks, there is no unified model of conceptualization and explanation in cognitive psychology (cf. Greeno, 1978; Resnik & Ford, 1981; Michener, 1978). Many approaches, however, have been based on a problem solving model which was already developed by Polya (1966) for working on mathematical problems. Solving a task requires the following: previous knowledge, in order to be able to understand the task; recognition of that which is sought; knowledge concerning the proper algorithm of solution and permitting to find the proper solution; knowledge about the connection of a problem with related problems. Categries 6.1 to 6.7 refer to these conditions of understanding as a cognitive process, and they are used were explanations referring to the tasks occur.

Causes like motivations, working behavior etc. (see table 1) are recorded twice – both task – specific and extending across tasks. Besides, explanations were included which only extend across tasks, such as influences external to school or the pupil's general speed of work.

This system was used by an independent coder to code the answers. For 50 explanations selected at random, a second coding was carried out by another coder for purposes of control; there was agreement in 87% of cases, which can be considered sufficient.

The extensiveness of the explanations can be judged from the number of categories used for any combination tasks/pupil, i.e. per line of the data sheet. Its mean was 2.4 categories, the number extending from 1 to 5 categories. A total of 975 explanatory concepts was identified. Multiple use of the same category in one pupil/answer combination was permitted – for instance for describing different areas of previous knowledge.

Results:

Question 1) Explanations referring to tasks or explanations extending across tasks

For the first two questions of the study, the frequency of causes named shall be considered across all teachers and tasks (see table 1)

PLEASE INSERT TABLE 1 HERE

There is a marked predominance of explanations referring to tasks (domain – specific) (679 = 69%) as compared to categories extending across tasks (205 = 21%) (Other categories 91 = 10%. The proportion of "other" categories is mainly due to category 6.7 "Mere description of the course of work", which is an answer referring to the task, but considered as a residual category, as it contains no explanation.)

The preference for explanations referring to tasks is mainly due to the fact that knowledge and procedures of understanding as elements of the problem – solving process (category group 6) were drawn upon in the first place. The causes referring immediately to the process of work resp. of thinking occurring during work on a task amount to 44% of all concepts named. If mere descriptions of the course of work are added, the percentage rises to 54%. This difference also shows for those categories which served to describe both the use referring to a specific task, and the use extending across tasks. Thus, the motivation referring to the task is named twice as often as general motivation; notwithstanding that motivation plays an inferior role as a concept of explanation. Observable working behavior in case of the particular task is named twice as often as observable working behavior in general.

A similar picture emerges from a comparison of the categories "characteristics of the lesson when treating specific tasks" and "general characteristics of the lesson" (5.1% vs. 0.6% of items named). It is also interesting that little emphasis is placed on features of memory in the sense of an ability to recall, and the most emphasis is places on the pupils' previous knowledge in the case of the particular task.

The observable working behavior on the task (category 8) is the third most frequently named – more evidence for the fact that "understanding" is explained directly on the basis of the pupil's concrete working on the task.

Among the explanations extending across tasks, "styles of thinking" (cat.10) are most frequently named (43 = 4.4%). This comprises explanations such as logical thinking, abstract or concrete thinking etc., i. e. qualities of the process of thinking which do refer to the topic, but do not immediately refer to the task or to the particular subject matter area.

Question 2) Steps and Conditions of Understanding

We consider the relative frequencies of items named which belong to category group 6 as indications of the ideas teachers have of the cognitive process of understanding in pupils. Thus, understanding the task is mainly considered to be the necessary implementation of a process of solution clearly sketched in the instruction, or as recognition and recall of an idea of solution. Category (6.3) "recognizing or recalling the idea of solution" is used much more often than "independent development of the idea of solution" (6.4). Nevertheless, this does not necessarily imply a conception of mechanical reproduction of a subject matter once learned. Thus, the category "recognizing the connection with other tasks" (6.6) and the category "recognizing the solution sought" (6.2), i.e. recognizing that which is indetermined in the task, are not much less frequently named (6.7% resp. 7.5% of items named). The special role of previous knowledge, as well as the relatively frequent naming of the importance of the connection with other tasks points to the integration of the understanding of a task in the preceding tasks, and thus into a larger context. The other conditions frequently named which do not immediately belong to the cognitive steps of understanding also indicate that understanding is integrated into the flow of the lesson. The pupil's general working behavior (cat. 7 = 4.4%) and working behavior with regard to task (cat. 8 = 8.6%), as well as the "characteristics of teaching when treating specific task" (cat. 15 = 5.1%) are classroom events, too.

Question 3) Differences in the Explanation of Understanding/ Non – Understanding between Boys and Girls

Sutcliffe's (1957) contingency analysis<+> was used to test the differences of frequencies for

understanding/ non – understanding and boys/girls for the 14 categories which had been named at least 20 times. This analysis permits to dissect contingency tables into main effects and interaction effects. The testing was done against the original distribution of boys and girls named for understood/not understood – see below.

The following categories showed main effects for the variable of understanding vs. non – understanding: category (3) "attention" (χ^2 = 4.94, p <.05) is used more frequently to explain nonunderstanding than to explain understanding. As opposed to that, cat. (6.6) "recalling or recognizing the idea of solution" is used more frequently to explain understanding than to explain non – understanding (χ^2 = 6.09, p <.05). "Mere description of the course of work" (cat. 6.7) was found more frequently in explanations of non – understanding than in explanations of understanding (χ^2 = 12.62, p <.001). Category (8) "observable working behavior with regard to task" was used more frequently to explain understanding than to explain non – understanding (χ^2 = 5.90, p <.05).

The pupils' sex was important for two categories only. In category (7) "observable working behavior", an interaction effect was evident (χ^2 = 4.54, p <.05): for boys, working behavior was used more often to explain understanding, while it was used more often to explain non – understanding in girls.

For cat. (15) "characteristics of teaching when treating specific task", there was an effect of interaction. For girls, it was used more often to explain understanding than to explain non – understanding, while there was no such difference in case of boys (χ^2 = 4.21, p <.05).

With these two exceptions, the explanation did not differ with regard to sex. There was, however, already a sex – typical feature in the selection of pupils and in assigning them to the categories of understood/ not understood. As teachers had an equal number of boys and girls to select from, the total distribution of boys and girls with regard to the conditions understood/ not understood was tested against an equal distribution by Sutcliffe's contingency analysis – see table 2. The result was that boys

PLEASE INSERT TABLE 2 HERE

who had understood a task were named significantly more frequently, and girls who had not. That boys show better achievement and thus will understand a task more frequently than girls is no valid explanation. The average grade for the boys in mathematics is 2.9, for the girls it is 3.0.

Discussion: Reference to the Task and Type of Explanation

The large difference between the frequencies of categories referring to tasks and of categories extending across tasks is salient. The explanations given mainly refer to the process of work and of thinking in case of specific tasks, and thus to areas of subject matter. This does not mean that teachers argued with the "logic" of the tasks only, leaving psychological aspects aside. Rather, the teacher explanations presented here can be seen as cases of specific

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+ The values were calculated on a personal computer; the program has been developed by Gerd Mannhaupt.

integration (one could also say "applications") of psychological concepts with the mathematical – technical features of tasks and topics. The process of understanding is predominantly explained by characterisitics of the situation, and with pupil characteristics which can immediately be inferred from observable behavior (e.g. recalling or recognizing the idea of solution). It was also shown that a psychological model of problem – solving is appropriate to code the teachers' representations of the process of understanding. This requires, however, that the insertion of tasks into sequences of tasks and teaching topics is taken into account. Further, it must be remembered that the tasks did not require the solution of totally unfamiliar problems, but of using knowledge already taught. If "subjective" concepts of explanation are assigned to "objective" scientific explanations of understanding, it can be shown that teacher tend to prefer "constructivist" theories of understanding, considering above all the application of knowledge already present as constitutive for the process of understanding "new things" – i.e. they tend towards a basic idea of modern research into problem – solving.

Insofar, the results can also be interpreted as a contribution to research into representations about the concept of "understanding". As there is no unified conceptualization of "understanding mathematical tasks" in psychology, it is promising to investigate the ideas about understanding of practioners whose profession it is to develop and promote understanding.

Only in case of few categories there were significant differences between the explanations of understanding and of non – understanding. The explanations of non – understanding concern necessary, but not sufficient conditions of understanding. If there is no previous knowledge of the subject matter area, or inattention, there will be no further steps in the process of understanding during which other causes of non – understanding can appear. As opposed to that, "recalling or recognizing" the solution – which has been prepared or treated before – seems to be the decisive step to understanding which is named more frequently in case of understanding than in case of non – understanding. There are several possible explanations why a mere description of the course of work was given relatively frequently for non – understanding in particular. One possibility is that non – understanding was considered to be directly due to the logic of the task which says that step B cannot be taken if step A did not succeed. The fact that previous knowledge is also used more to explain non – understanding is in favor of this interpretation. Another interpretation is that non – understanding permits a better insight into the cognitive process of working on a task than would be provided by a process of understanding which runs "smoothly" and becomes recognizable for the teacher only from its result. Besides, a more precise localization of the moment of non – understanding in concepts of procedures of working on a task is particularly necessary for the teacher's coping with his own task – it is only this which enables him to intervene at a precise spot and to enhance understanding.

The results as to sex – typic perception show only slight differences. It was shown that boys were selected more often to explain "understanding", and girls more often to explain "non – understanding". The differences in the kinds of explanation given concern the items "observable working behavior in general", and "characteristics of teaching when working on task". The former difference is congruent with the well – known fact that the working behavior of girls is judged differently from that of boys (Schildkamp – Kündiger, 1982).

Obtaining Explanations Referring to Task: Problems and Opportunities

Naturally, there are some limitations in generalizing the results of studies such as the one presented here. Thus, the number of teachers questioned (20) is relatively small – although big for studies with teachers carried out under natural conditions. Further, the problem of inter-

individual differences was not pursued – we have, however, attained both a homogenization of teachers according to sex, class taught, school type and subject, and a limitation of the age span to 12 years of professional experience.

The prevalence of explanations referring to tasks and specific for areas of subject–matter as opposed to explanatory concepts extending across areas indicates that the respective specific elements of subject matter content within the perception and explanation of psychological facts (such as the pupils' understanding) should be increasingly taken into account in research into teacher cognitions. Our results illustrate the findings of Rheinberg & Elke (1979) which say that teachers have complex causal hierarchies of explanations at their disposal – the question of the internal structure of explanations having to be clarified in further studies.

It may be that the results have been obtained because of the fact that the respective task was just as concretely given as the pupils whose effort to understand was to be explained, and that both had been taken from the teachers' actual everyday experience. Hence, the task was not characterized by just one parameter, e.g. degree of difficulty. It may be assumed that the high proportion of the explanations referring to task and specific for areas was influenced by this presence of the concrete task.

Even under this condition, however, the emphasis was not only on repeating steps of working at the task, but on giving psychological explanations referring to the tasks as well. The equal salience of tasks and pupils given by the method would seem to be appropriate for the question pursued here i.e. the teacher's explanations during his daily work in the classroom, and it seems to be necessary to attain ecological validity. It is one of the teacher's tasks to enhance his pupils' understanding in case of specific tasks – and in order to do this, information about the pupil and information about the task must be related to one another. Only this information enables him to plan and implement the next steps of teaching, with regard to the entire class or to individuals which have to be encouraged. For this task, global assessments of cognitive or motivational pupil characteristics are only of very limited value. The results show that the teachers investigated have concepts at their disposal which enable them to meet the demands of their work. "Explanation" is given rather more with low inference than with high inference concepts.

This result is plausible – as measured against the practical purpose of such teacher explanations. The "causes" named by the teachers actually concern those factors they are able to influence – at least indirectly.

fig. 1

Schematical representation of a data sheet

task		
task understood	name	reasons for understanding
	name	
task not understood	name	reasons for not-understanding
	name	

Table 1: Frequency of the Categories Used

		u ♂	u ♀	nu ♂	nu ♀	Total %	Total absolute
1. General Motivation	(e)	2	4	4	4	1,4	14
2. Motivation ref. to task	(r)	9	7	5	9	3,0	30
3. Attention	(e)	3	2	10	5	2,0	20
4. Self-Confidence	(e)	0	0	2	5	0,7	7
5. Memory	(e)	1	1	0	1	0,3	3
Knowledge and Procedures of Understanding							
6.1 Previous knowledge of the task related subject-matter	(r)	35	27	40	43	14,9	145
6.2 Recognizing the solution sought	(r)	23	15	13	22	7,5	73
6.3 Recalling or recognizing the idea of solution	(r)	30	26	15	18	9,1	89
6.4 Elaboration of an idea of solution by the student	(r)	1	4	0	0	0,5	5
6.5 Implementing the idea of solution	(r)	19	17	11	14	6,3	61
6.6 Recognizing the connection with other tasks	(r)	22	15	14	14	6,7	65
6.7 Mere description of the course of work	(o)	16	8	24	32	9,2	80
6.8 Other items of the process of problem solving	(r)	4	4	1	3	1,2	12
Total of categories 6.1 to 6.8:		150	116	118	146	54,0	530
7. Observable working behaviour in general	(e)	9	16	10	8	4,4	43
8. Observable working behaviour with regard to task	(r)	31	22	14	17	8,6	84
9. Speed	(e)	4	2	3	5	1,4	14
10. General styles of think.	(e)	13	7	7	16	4,4	43
11. General giftedness	(e)	3	1	1	0	0,5	5
12. Giftedness ref. specifically to math topics	(r)	1	3	4	2	1,0	10
13. Task characteristics	(r)	18	12	13	12	5,6	55
14. Gen. charact. of teaching	(e)	1	1	2	2	0,6	6
15. Characteristics of teaching whilst treating task	(r)	10	20	9	11	5,1	50
16. Homework	(e)	5	7	5	2	2,0	19
17. Gen. evaluat. of achievem.	(e)	7	7	4	5	2,4	23
18. Non-school influences	(e)	1	3	3	1	0,8	8
19. Impossible to code	(o)	2	4	2	3	1,1	11
Total frequency of categories:		270	235	216	254	100 %	975
Pupils named:		111	88	91	109		399*

*There is an total of 399 pupils named, as one of the teachers named only 3 pupils for one task.

e = categories extending across tasks
r = categories referring to tasks
o = other categories / residual categories

u = understood
nu = not understood

table 2

Frequency of girls and boys named under the conditions "understood" and "not understood"

a) for all subject matter areas from which tasks were taken

b) according to individual topical areas

	understood		not understood		x^2	p
	boys	girls	boys	girls		
a) all areas	111	88	91	1o9	4.22	< .o5
b) arithmetics	37	25	25	37	4.64	< .o5
algebra, set theory probability calculus	28	15	18	26	5.11	< .o5
percentage calculus	2o	2o	19	21	.o5	
geometry	26	28	31	23	.93	

Zusammenfassung

In Modellen effektiven Lehrerhandelns wird die Wichtigkeit der optimalen Passung von Schülermerkmalen und Merkmalen des Unterrichts betont. Es wird empirisch untersucht, über welche Erklärungskonzepte Mathematiklehrer verfügen, die eine solche Passung erst ermöglichen. Mit einem speziell entwickelten Erhebungsverfahren werden bei 20 Gymnasiallehrern der Sekundarstufe 1 freie Erklärungen zum Verständnis konkreter Aufgaben ihrer Schüler erhoben. Diese freien Erklärungen werden nach 26 verschiedenen Kategorien ausgewertet. Dabei wird insbesondere der Frage nachgegangen, ob die Erklärungen eher aufgabenbezogen (z.B. Vorkenntnisse) oder eher aufgabenübergreifend (z.B. Begabung) erfolgen. Außerdem wird nach Zusammenhängen mit dem Geschlecht der Schüler und dem Erfolg bei der Aufgabenbewältigung gefragt.
Die Ergebnisse zeigen, daß aufgabenbezogene Erklärungen deutlich häufiger auftreten als aufgabenunabhängige. Der Erfolg der Aufgabenbearbeitung und das Geschlecht der Schüler haben einen - wenn auch schwachen - Einfluß auf die Art der Erklärungen des Lehrers. Es werden abschließend die Möglichkeiten des Erhebungsverfahrens diskutiert.

Summary

Models of effective teaching stress the importance of matching student and subject matter characteristics.
This study reports on an empirical investigation into the explanatory concepts of teachers as an important prerequisite of effective matching. The explanatory concepts of 20 junior high school teachers concerning their students' comprehension of mathematical tasks were probed into using a specially designed method. After a categorization of the explanations into 26 conceptionally different categories, the analysis of the data focused on the importance of task-related (e.g. knowledge) vs. task independent concepts (e.g. giftedness). Additionally, the relations between the use of explanatory concepts and students' sex and success with the task were taken into account. Results show strong preference for task-related concepts. Both student characteristics were of limited influence only. The discussion includes a consideration of both the possibilities and limitations of the method proposed.

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